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ABSTRACT

An exploratory study was undertaken to provide a means of quantifying some of the components of the problem solving process. The focus was on actual problem solving behaviors and strategies as they occurred in relation to different cognitive tasks and subject characteristics. Cognitive tasks included items from Wechsler and Binet intelligence tests, simple mathematical tasks, and verbal and performance tasks. The data for the study were provided by tape recordings of the 'thinking aloud' protocols of the individual attempts of 89 adults to solve 12 tasks each. All protocols were transcribed verbatim, timed in units of 3-second intervals, and categorized according to the taxonomy of 18 strategy variables. The unit of analysis was the 3-second interval, classified according to strategy content. The problem solving behavior documented in this manner on the 12 tasks per subject yielded a total of 41,960 responses, time sequence of responses having been kept intact for each subject and task. Initial results indicate that quantifiable features of the problem solving process may provide a means for the description of performance differences between subjects of varying levels of measured intelligence, competence and speed of problem solving. (Author/RL)

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MEASURING THE NATURE OF PERFORMANCE DIFFERENCES:
A PROCESS APPROACH

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Abstract

Following Carroll's (1978) suggestion and arguments for the use of 'Psychometric Tests as Cognitive Tasks', a study of performance differences of 89 adult subjects in 12 problem solving tasks was performed. The investigation did not restrict itself to the products, i.e. outcomes, of problem solving but revealed qualitative features of the solution process, which are quantifiable. A taxonomy, based on empirical data, was developed for the classification of component behaviours during the problem solving process.

The data for the study were provided by tape recordings of the 'thinking aloud' protocols of the individual attempts of 89 adults to solve 12 tasks each. All protocols were transcribed verbatim, timed in units of 3-second intervals, and categorized according to the taxonomy of 18 mutually exclusive, all inclusive, strategy variables. The unit of analysis was the 3-second interval, classified according to strategy content. The problem solving behaviour documented in this manner on the 12 tasks per subject yielded a total of 41960 responses, time sequence of responses having been kept intact for each subject and task. The tasks used included items from Wechsler and Binet intelligence tests, simple mathematical tasks, and verbal and performance tasks previously reported in the research literature.

Distinctive strategy patterns manifested themselves in relation to subject characteristics, tasks, and a combination of both. Initial results indicate that quantifiable features of the problem solving process itself may provide a means for the description of performance differences between subjects of varying levels of measured intelligence, competence and speed of problem solving.

The aim of the study which I am discussing here was to attempt to account for observed differences in the performance of individuals on a number of cognitive tasks in terms of the psychological processes which take place during such performances. In other words in an endeavour to aid the discovery of generally or specifically relevant principles of cognitive behaviour, the problem solving strategies used by a variety of subjects during their attempts to solve a diversity of specific tasks were investigated.

This type of research is regarded as important because it might be expected to contribute eventually to an improved understanding of concepts relating to intelligence, abilities, achievement etc. and the phenomenon of individual differences.

Since Binet (1905) the measurement of intelligence has been based on observed differences in individuals' performances on a variety of problem solving tasks. The general rationale for these collections of tasks, or 'intelligence tests', is based on the sometimes implicit assumption that the 'intelligent' person has accumulated a considerable amount of knowledge, and is able to solve problems. The latter aspect of intelligence is frequently defined as the ability to deal successfully with new situations (Wechsler, 1958).

Difficulties facing the designers of traditional intelligence tests have increased in recent times as a result of the problem of the sampling of items which are representative of the already vast and now exponentially increasing body of knowledge to which an individual may have been exposed. Some information scientists have estimated that the extent of knowledge may be increasing at a rate of between 8 and 15 per cent per annum (Garfield, 1974, 1977). The reduction in validity of traditional intelligence tests which has resulted from the recent growth in the rate of information accumulation, combined with changes in social attitudes, the public questioning of issues concerned with the validity and legitimacy of measures of human abilities (e.g. Block and Dworkin, 1976; Cole, 1972; Darlington, 1971; Fincher, 1976; Fine, 1975; Horn, 1976; Houts, 1977; Humphreys, 1973; Jensen, 1969, 1973; Kamin, 1974; Loehlin, Lindzey and Spuhler, 1975; Scarr-Salapatec, 1971; Schmidt and Hunter, 1974; Thorndike, 1971), and changes in educational philosophy and practice (e.g. Bloom, 1964, 1971; Cronbach and Snow, 1977; Elam, 1964; Gagné, 1965) have led to the need for a better understanding of the concept of intelligence than appears to have been required in the past.

From its beginnings the intelligence test was designed specifically to serve in the selection of people, and the prediction of academic achievement. Educational decisions tended to be made on the basis of the estimates of intellectual potential, provided by the scores on these traditional standardized tests of general ability. In contrast to this, more recent developments emphasize the malleability and adaptive functional development of cognitive skills. Glaser, Pellegrino and Lesgold (1977), in their discussion of 'Some Directions for a Cognitive Psychology', emphasize this change and strongly recommend

that the most significant use of measures of intelligence and aptitude should not be primarily for the purposes of prediction, but for indicating how intellectual performance can be improved. (p.508)

Traditional intelligence tests have been useful in the context for which they were designed. Even if it were possible to produce updated versions of such tests, reflecting the knowledge surrounding individuals at the present time, this type of test is unlikely to contribute to the aim of improving intellectual performance because it does not provide any interpretation of general ability or aptitudes in terms of variables which enhance or impede cognitive performance, and which might thus be of educational relevance.

Focusing on the products, mainly the success/failure aspect of problem solving, has tended to block access to information about the way in which factors within the task and the performance itself may have contributed to the outcome of problem solving. The time taken to solve a task, the correctness, even the 'elegance' of the solution, have traditionally served to evaluate performance. This approach has obvious limitations when the aim is to describe the performance processes of an individual, and to intervene in order to change performance by increasing the problem solving ability or efficiency.

In order to achieve this aim, it is necessary to analyse the performance itself with a view to identifying the components of performance which might generate the individual differences frequently observed in the performance on such tests. The fact that many of the often unpretentious tasks included in individual and group intelligence tests discriminate so effectively between people would suggest that studies of the processes involved in carrying out the task seem warranted.

Factors of intelligence, the relationships between the performances on certain tasks, and the skill factors of various types, repeatedly identified in factor analytic studies have certainly made a significant contribution to

intelligence research and intelligence tests. But the general restriction of this approach to performance measures, i.e., the outcome of intelligent behaviour, e.g. of problem solving activity, has left unasked such questions as (1) what types of activities or processes operated during performances, and (2) how could one measure the variables which might be responsible for observed differences in performance. The latent variables which were postulated could not be observed directly, and could therefore not be operationally described or combined with other variables.

Though largely disregarded in traditional mental measurement, the structure and dynamics of the process of human problem solving have been of interest to experimental psychologists at least since Helmholtz (1894). It is difficult to summarize the literature because research has tended to be diverse and non-cumulative. Previous research findings have not provided comprehensive descriptions or explanations of cognitive processes such as the problem solving which takes place when individuals work on intelligence test items, make decisions etc.

However, various aspects of problem solving have been investigated in isolation.

The Gestalt approach (Köhler, 1927; Koffka, 1935; Wertheimer, 1923) was mainly philosophical. The constructs under investigation, e.g. 'incubation', 'insight', 'understanding', were ill-defined and appeared to be inaccessible to empirical study. The behaviourists, in their commitment to 'objective' measures of overt behaviours, emphasized the manipulation of problem solving processes and the understanding of influences of environmental controls on performance. Explanations were sought for the mechanisms by which elements of the problem solving process combine into more complex compounds. In general behaviourists did not aim to describe the contents of the psychological processes which take place during problem solving, but tended to explain them by postulating hypothetical constructs.

Information processing and artificial intelligence research moved from the investigation of problem solving on the basis of relationships between isolated elements of the process to focus on the contents of the process, i.e. the components of the process as sequential behaviour. Attempts were made to map the problem solving processes (represented as problem solving behaviours or strategies) of individuals on the basis of perceived solution requirements of the task. Even this approach has not revealed sufficient information about the problem solving process. It resulted in a large number of task specific, and frequently subject specific models.

Information processing and artificial intelligence research were able to analyse problems and specify task demands by a careful matching of monitored or simulated problem solving behaviours employed by single subjects in relation to specific tasks. While the results of this type of research were of considerably greater direct behavioural relevance than those of the previously noted approaches, none of these approaches served to reveal much information about the processes which might operate during problem solving more generally, in other words, how people solve problems.

Information processing psychologists are particularly concerned with the form in which information might be stored and transmitted (e.g. Anderson, 1976; Chomsky, 1955; Greero, 1973; Miller, Galanter and Pribram, 1960), with variables which might place constraints on human performance and with cognitive processes but largely ignored individual differences. Newell and Simon (1972) and others (e.g., De Groot, 1965; Rummelhart & Norman, 1975), investigating information processing, though generally concerned with the identification of processes used by particular individuals, have attempted to identify processes which might account for the performance by groups of individuals on particular tasks. In the latter case processes or rules of behaviour are postulated and predictions of their occurrence are compared with averaged performance data obtained from the groups. While attempting to generalize beyond the single case, this approach ignores individual differences in relation to the subjects, the tasks, and the combination of both of these. The only group concerned with individual differences per se have been the psychometricians.

Psychometric research did not aim to describe intelligence test performance in terms of the psychological processes which might underly or contribute to intelligence test performance. In contrast to this, experimental and information processing psychology set out to develop models and theories aimed at providing an understanding of problem solving performance, but tended to disregard individual differences. The situation was summarized aptly by Whitely (1977):

The different approaches of experimental psychology and psychometrics have resulted in practically important measures of intelligence which are not understood, in addition to cognitive theories which have no practical implications for measuring individual differences (p.465)

The term problem solving process has traditionally been applied to the characteristics of problem solving performance. In order to obtain information as to how these performance characteristics affect the outcome of problem solving activity, behaviourists focused on situational variables, Gestaltists on built-in mechanisms in the subject, and information processing research focused mainly on characteristic requirements of the task. All three dimensions are of utmost importance. What is required is a redefinition of the term problem solving process which permits it to cover performance-, subject-, and task characteristics and their interactions simultaneously.

Any research concerned with the question how people solve problems, must be performed within a framework which takes into consideration variables from at least three expected major sources of variation, namely characteristics of the psychological mechanisms which operate during performance, individual differences, and the task. A process model of problem solving should be consistent in terms of all three domains, and should account for interactions between these domains.

To design an empirical study of the problem solving process is particularly difficult, not only because of the complexity of the mechanisms which might be involved, but because the processes of interest tend to be covert and thus escape the investigator. The first aim in the present study was therefore to find a means of uncovering some of the components of the problem solving process so that a useful description of at least some structural and dynamic elements of this complex human behaviour could be provided. The pursuit of this aim is facilitated by the present intellectual climate, which once again permits the investigation of psychological processes. In addition to this, whatever psychological phenomenon is investigated is regarded as having been generated by an actively exploring individual within an interaction system which includes psychological processes, environmental influences, and a variety of individual needs and goals. The interaction of these results in different outcomes, e.g., differences in problem solving competence, aptitude, etc.

It is unlikely that an understanding can be achieved by attempts to add together the findings and contributions obtained in separate studies from these different perspectives. Incompatibility of research questions, design, and theoretical frameworks makes this difficult, if not impossible. What is required is a synthesis of information obtainable in the different domains. A prerequisite for such a synthesis is a research design which allows the

investigation of the problem solving process as a comprehensive system. This can only be accomplished if ways are found to represent what is going on during the problem solving process by measures which are sensitive, compatible, and complementary to each domain.

An understanding of the psychological mechanisms operating during problem solving demands the identification of important and replicable problem solving behaviours. Consideration of the task provides a basis for judgments concerning the generality or specificity of the identified problem solving behaviours. Accounting for individual differences requires the identification of a measure which correlates with various kinds or levels of ability. Concern with the interaction between the process, dimensions of individual differences, and characteristics of the task leads to a consideration of the problem solving process which is comprehensive enough to allow for the investigation of task or person dependent problem solving styles, or both.

To summarize, the research reported here was an attempt to identify empirically and classify the behaviours that individuals exhibit during their attempts to solve a variety of tasks. This required the identification of a set of behaviourally specific components of the problem solving process, which were expected to promise broader applicability across tasks and subjects, a selection of a variety of tasks, and the selection of a variety of individuals.

The major questions posed for the study included the following:

- 1 What types of problem solving behaviours or strategies do individuals apply during the problem solving process?
- 2 How do a number of contextual variables (e.g. problem solving competence, speed, measured intelligence, and level of education) affect the problem solving process?
- 3 In what way are problem solving processes influenced by characteristics of the task?

More specifically, answers to the following types of questions were sought.

- 1 Do individual subjects show preferred problem-solving strategies irrespective of task or item type?
- 2 Are there preferred problem-solving strategies for all tasks?
- 3 Are problem-solving strategies constant in frequency across task types?

- 4 Does the task or item type dictate the pattern of problem-solving strategies?
- 5 Do preferred strategies lead to greater efficiency and speed?
- 6 How do efficiency and speed relate to problem solving strategies?
- 7 How do strategies relate to each other in time series?
(Dependency of strategies on antecedent problem-solving behaviours.)

Conceptually and in its design this study has drawn from the findings of a large number of research studies, representing all previously discussed interpretative frameworks, published in the literature. The strongest influence both in conceptualization and methodologically was exerted by the position reflected in information processing research, in particular by the work of Newell and Simon (1972). Gestalt psychology strengthened the interest in process oriented research. The behaviouristic framework was responsible for the concern to use low inference measures in the present study. Psychometrics contributed the interest in individual differences, and factor analytic procedures appealed as a method of data reduction and analysis.

The work of Newell et al. (1958), Newell and Simon (1972), Ericsson (1975), Buswell (1956), Krutetskii (1976), and others provided convincing recommendation for the utilization of the 'thinking aloud' procedure as a promising means to externalize at least some of the generally covert behaviours operating during the problem solving process.

It was assumed that the 'thinking aloud' protocols would provide information about the problem solving behaviours and strategies used by the subjects and would therefore provide some insights into the problem solving process. Also it was assumed that the task type and certain subject characteristics might affect the problem solvers' strategies, and that such an effect, if found, would be reflected in the 'thinking aloud' protocol.

The dimensions examined in this study were selected on the basis of their perceived relevance in the problem solving context. The research literature, designers of psychological tests, educational and organizational psychologists, and others have stressed the importance of such variables as competence, speed, intelligence, and, of course, the characteristics of the task, and their relationship to cognitive activity and performance. An understanding of the operation of such factors in the problem solving context can be expected to lead to an improvement in predictive and diagnostic measures, as well as to the development of methods aimed to produce more effective problem solving behaviours.

The subject characteristics, the influence of which was investigated in the present exploratory study, were therefore represented by the variables of problem solving competence, speed, and an estimate of measured intelligence. For most of the analyses two levels were assigned to each of these three variables, although three levels were assigned to the competence variable for some analyses.

By requesting each individual to solve a number of different tasks and by grouping subjects on the basis of a number of criterion variables, i.e. competence, speed, intelligence, it became possible to compare the effects of various levels of these variables on the problem solving behaviours used during the problem solving process. The monitoring of the problem solvers' progressive behaviours and strategies in sequence provided information about the process. Attempts were made to analyse the problem solving behaviours emerging from the protocols, both in terms of aggregate frequencies of the types of strategies used overall, and on the basis of their sequential pattern of occurrence. The latter analyses allowed some initial exploration of the dependency between different problem solving behaviours.

The 'thinking aloud' protocols and the subjects' positions on the criterion variables were analysed in relation to the questions raised for the study. The most time-consuming aspect of the study was the analysis of the protocols to obtain the data on the basis of which the problem solving process was to be investigated. This analysis involved the following major steps:

- 1 The cassette-recorded 'thinking aloud' protocols were transcribed verbatim, keeping all behaviour sequences, including pauses, intact.
- 2 The transcribed protocols were divided into three-second units.
- 3 Each three-second unit was classified on the basis of a previously prepared taxonomy of 18 empirically obtained problem solving behaviours. This procedure yielded a total of 41,960 problem solving responses for the 89 subjects' attempts to solve 12 tasks.
- 4 The protocols from ten randomly selected subjects (i.e., 4598 three-second response units) were scored by two independent judges so that the reliability of the taxonomy could be assessed.

The previously detailed research questions were investigated as follows:

Question 1: What types of problem solving behaviours or strategies do individuals apply during the problem solving process?

The design of the present study implied that problem solvers themselves might provide some information about the methods and behaviours they employ during their attempts to solve problems. The benefit of determining empirically the types of problem solving strategies used by subjects lies not only in the potentially increased understanding of the processes involved, but in the possibility of identifying means by which problem solving ability might be improved. Identification of strategies provides basic information about the ways in which problem solvers interact with the task. For example, whether they are attentive to the instructions, whether they are creative, convergent, or divergent thinkers, - whether they make appropriate use of the given input information - whether they anticipate the possible outcomes of their hypotheses and refer to their memory in order to apply their own background experience to the given problem.

Answers to Question 1 are thus contained in the application of the taxonomy which was developed on the basis of empirically identified problem solving behaviours. Preferences for certain strategies were identified in relation to individual subjects and tasks by calculating the frequency with which each strategy was used by each subject while working on each task. Usage of problem solving behaviours was also investigated for each subject as a proportion of the total number of problem solving behaviours exhibited by that subject in relation to a particular task.

Question 2: How do a number of contextual criterion variables (i.e. level of education, problem solving competence, speed, and measured intelligence) affect the problem solving process?

The investigation of this question is of particular importance to the possible teaching of problem solving skills and to educational planning in general. If problem solving ability and levels of intellectual functioning, for example, could be operationally defined in terms of problem solving behaviours and strategies, useful information might be obtained about hitherto inaccessible cognitive processes and the factors which might influence them.

Individual differences in problem solving performance and correlates of problem solving ability and measured intelligence have been investigated

in the past, but little is known about the actual behaviours and strategies which might underlie these performance differences, and about the manner in which such processes may differ between individuals with varying characteristics.

Question 2 was therefore explored by comparisons of the problem solving behaviours used by solvers with those employed by non-solvers and by those subjects who decided to discontinue the task prematurely. The patterns of problem solving behaviours of fast and slow working subjects were compared in a similar manner. Measured intelligence was used as a classification variable rather than as a criterion in most analyses, firstly because of the coarseness of the estimate of this criterion, and secondly because of the smaller number of subjects taking part in the study whose IQ estimate placed them outside the average (i.e., mean + 1SD) region, and because of gross variations in the distributions of the dependent variables.

In the descriptive analysis of the sequential data some extreme IQ group comparisons were included. To answer Question 2 the frequencies of use made of each behaviour were compared for the 12 tasks for subjects of different problem solving competence and speed. The variety of different strategies used was investigated as well as the frequency with which the strategies were employed. Multiple discriminant functions were computed to ascertain whether specific sets of problem solving behaviours would be able to discriminate between the criterion groups.

Question 3: In what way are problem solving processes influenced by characteristics of the task?

The problem solving process consists of the interaction between the problem solver and the task on the basis of which the problem solving takes place. Because of this, characteristics of the task, such as its type, length, difficulty, etc., can be expected to exert considerable influence on the problem solving processes. Although certain differences between tasks, for example, between verbal and performance items, are generally accepted and regarded as obvious, their differential effects on problem solving behaviours have not been investigated. An understanding of the effect of task specific characteristics on problem solving behaviour might lead to the addition of an operational definition of the concept of task difficulty level to the psychometric one, and might thus provide a basis for the identification and teaching of effective strategies for the solving of different types of problems.

To answer Question 3 the total amounts of use made of each behaviour category and the transition behaviours for all subjects were compared between the 12 tasks. Other explorations of the influence of the task included the comparisons of the first principal components obtained from task specific analyses, of preferred problem solving behaviours, the comparison of preference ranks and average usages of problem solving behaviours between the 12 tasks. These analyses provided some means to determine whether the processes of problem solving were differentially affected by the characteristics of the task. In other words, it was possible to investigate whether the task determines the problem solving behaviours and strategies.

The contextual variables of problem solving competence, speed, and measured intelligence were investigated in combination by means of a $3 \times 2 \times 2$ analysis of variance of the mean frequencies of usage of the different behaviour categories across all tasks.

Finally three-mode factor analysis (Tucker, 1966) for subjects $\times$ strategies $\times$ tasks was performed to investigate the problem solving process in a more comprehensive way.

The above discussed questions were explored mainly in relation to aggregates of the amounts of use made of various problem solving behaviours by each subject on each task. The concern was to investigate certain structural components of the problem solving process and to establish their relative importance. In an attempt to analyse the dynamics of the problem solving process, an attempt was made to investigate behaviour sequences as they occurred. An attempt was made to further investigate the previously posed three major questions on the basis of sequential problem solving behaviours.

It was assumed that the further the occurrences of sequential problem solving behaviours are removed from one another in time during the problem solving process, the lower is their dependency. Because of this pairs of sequential behaviours immediately following one another were summarized as pairs making up the elements of one-dependent transition matrices, which were then analysed on the basis of a Markoff-chain model.

For each of the 12 tasks, three major types of comparisons of the transition matrices were made:

- 1 The overall transition matrices made up of the sequential pairs of solving behaviours were compared for groups of subjects of varying problem solving competence, speed, and measured intelligence.

- 2 The patterns of transition behaviours were compared along the time dimension for the total sample and the above mentioned criterion grouping in two ways:
 - (a) The overall trends in the occurrence of the behaviour sequences were investigated and compared for the beginning, middle, and end periods of the problem solving process.
 - (b) The same three-second segments were compared with regard to the relative contributions made by specific behaviour sequences to changes in the pattern of strategy usage over time
- 3 The rate of changes in problem solving behaviours and strategies over time and the relative amounts of repetitive behaviours were investigated in relation to individual and group differences.

The design of the study recognized that every attempt should be made to design research in such a way that it might yield reproducible findings across a variety of situations. The present study explored problem solving in relation to a number of different tasks and subjects. In addition to this, and following the concern of Harris (1967), Campbell and Fiske (1959), and others, a number of different statistical methods were used to analyse the data, the aim of the latter being a modest attempt to increase the reliability of the findings as far as they are determined by the chosen method of data analysis.

The study was an exploratory one, and has many limitations indeed. A number of these have resulted directly from the chosen method of data collection and analysis.

Most importantly, the validity of the findings of the study are limited by the validity of the 'thinking aloud' methodology and protocol analysis as sources of data about the problem solving process. The contents of the protocols were restricted to what subjects were able to verbalize about their behaviours and strategies during the problem solving process. Other behaviours, of which the problem solver was not aware or which were not expressed, may have occurred.

The validity of the study depended on the ability and willingness of the subjects to co-operate in the research by verbalizing their problem solving behaviour, on the investigator's ability to train the subjects in the 'thinking aloud' technique, and on the reliability of the taxonomy of problem solving behaviours on the basis of which responses were classified.

Another limitation of the study resulted from the selection of the subjects. The sample size was limited. Eighty-nine volunteer subjects performed all 12 tasks, and the population consisted of one class of Year 11, Year 12, first year undergraduate psychology, and second year Teachers College students. All subjects were older adolescents or adults. No consideration was given to developmental variables affecting the problem solving process. Future research will have to be concerned with the question of whether the findings of this study will hold for different age groups, and describe how patterns of preferred strategy use might change during development.

The design of the present study did not allow for the identification of motivational and interest variables, and their effects on the problem solving process. Problem solving, like all behaviour, must be expected to be influenced by motivation. The importance of these variables is recognized, and it is accepted that their effect on the problem solving process provides research questions of high priority. In the present study, in the meantime, it was assumed that all subjects had the same goal, namely to solve each task presented to them. It is acknowledged that individual differences in the strength of each problem solver's goal, which are determined by previous experiences, interests, and other motivational variables, interact in complex ways with the task requirements and characterize performance.

The procedure of requiring subjects to solve all problems in one session, and the presentation of tasks in the same set order, while providing some control of the experimental situation, may have affected the findings.

The findings of this exploratory study must be interpreted as tentative until they can be replicated with better and more representative samples. However, the purpose of the research was to explore empirically in a more comprehensive and in-depth way the problem solving process than has been done in previous research. A major aim was to provide a means of quantifying at least some of the components of the problem solving process. The results of this study were compared with those of other studies of the problem solving process. Areas of considerable agreement were identified. Despite its limitations the present study is, therefore, expected to make a useful contribution to the design of future research into the problem solving process.

To summarize, it might be said that in the study reported here the problem solving process was explored by means of a research design which focused on actual problem solving behaviours, and which allowed the investigation of behaviours and strategies as they occurred in relation to different tasks and subject characteristics.

The approach taken was novel, because although these components of problem solving have previously been investigated in isolation, they have not been explored in combination, so that all relevant dimensions of the problem solving situation could be explored independently but simultaneously, and as interactions with one another. The comprehensive approach to the investigation of the problem solving process used in the present study was facilitated by the use made of the 'thinking aloud' methodology, and by the application of multivariate statistical procedures, in particular by the availability of three-mode factor analysis. Strategy use was investigated as it was affected by both task and subject variables.

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